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Guidelines for Using Infrared Thermography for Condition of Rotating Components

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Non-Destructive Testing Sectional Committee, MTD 21

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards after the draft finalized by the Non-Destructive Testing Sectional Committee had been approved by the Metallurgical Engineering Division Council.

Infrared thermal imaging is used for nondestructive, non-contact detection of non-uniform temperatures as part of condition monitoring of compressors, motors, fans, pumps, and other rotating components in engineering industry. Early detection of temperature changes especially, hot spots, due to possible degradation, damage or flaws in rotating components using infrared thermography will enable prevention of failures and accidents. Periodic monitoring using infrared thermography helps in minimizing the down time of plant components.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

GUIDELINES FOR USING INFRARED THERMOGRAPHY FOR CONDITION OF ROTATING COMPONENTS

1 SCOPE

This guideline covers application of infrared thermal imaging method to detect non-uniform temperature and also to detect adverse distribution of heat during service, by mapping isotherms. Compressors, motors, fans, pumps, vacuum sets, conveyors etc, generally referred to as mechanical equipment. They have rotating components such as motor, shaft, pump, bearings, casings, couplings, v- belts, pulley, chain drives and gearboxes which are designed to transfer mechanical energy with minimal losses through friction. This guideline is applicable for condition monitoring of these components to detect hot spots. This guideline may involve use of equipment and materials in the presence of heated, moving or electrically energized equipment or all of these.

2 TERMINOLOGIES

For the purpose of this standard, the following terminology shall apply:

2.1 End User — The person responsible for using the information provided by an infrared examination.

2.2 Infrared Examination — The use of an infrared imaging system to provide thermal data about a structure, system, object or process.

2.3 Inventory List — A list of the equipment by the infrared thermographer.

2.4 Qualified Personal — Person provided and authorized by the end user to perform the tasks required by the infrared thermographer. He/she shall be knowledgeable of the operation and history of the equipment to be examined and of all safety practices and rules of the end user.

2.5 Qualitative Infrared Inspection — An infrared examination that provides images of exceptions but not temperature data.

2.6 Quantitative Infrared Inspection — An infrared examination that provides both images of exceptions and temperature data.

2.7 Absorptance — The ratio of radiant flux absorbed by a surface to that incident upon it.

2.8 Apparent Temperature — The temperature of an object as determined solely from the measured radiance, assuming an emissivity of unity.

2.9 Blackbody — An ideal thermal radiator (emissivity = 1.0) that emits and absorbs all of the available thermal radiation at a given temperature.

2.10 Emissivity — The ratio of the radiance of a body at a given temperature to the corresponding radiance of a blackbody at the same temperature.

2.11 Field of View (FOV) — The shape and angular dimensions of the cone or the pyramid which define the object space imaged by the infrared imaging system.

2.12 Infrared Imaging System — An apparatus that converts the two dimensional spatial variations in infrared radiance from any object surface into a two-dimensional thermogram of the same scene, in which variations in radiance are displayed in gradations of gray tone or in color.

2.13 Infrared Reflector — A material with a reflectance in the infrared region as close as possible to 1.0.

2.14 Infrared Sensing Device — One of a wide class of instruments used to display or record, or both information related to the thermal radiation received from any object surfaces viewed by the instrument. The instrument varies in complexity from spot radiometers to two dimensional real time imaging systems.

2.15 Infrared Thermographer — The person qualified or trained to use infrared imaging radiometer.

2.16 Infrared Thermography — The process of displaying variations of apparent temperature (variations of temperature or emissivity or both) over the surface of an object or a scene by measuring variations in infrared radiance.

2.17 Reflected Temperature — The temperature of the energy incident upon and reflected from the measurement surface of a specimen.

2.18 Thermal Resolution — The smallest apparent temperature difference between two black bodies that can be measured by an infrared sensing device.

2.19 Thermogram — A visual image which maps the apparent temperature pattern of an object or scene into a corresponding contrast or colour pattern.

3 METHODS OF TEST

The following methods are generally used on thermally generated electromagnetic energy by infrared radiation in non-contact mode.

3.1 Non-Contact Method

Non-contact method involves the use of TV/PC compatible infrared imager to continuously monitor the temperature distribution over a visible surface. A sudden but uncertain change in temperature of the surface is induced by brief exposure to a high power heat source or by contact with another material at a different temperature. Sub-surface flaws, such as delaminations, inclusions and voids affect the diffusion of the heat through the material, producing variations in surface temperature. The changing surface temperature patterns are scanned with an infrared imager and displayed on a computer screen, and the results are recorded on computer HDD/ removable disk for further analysis or image enhancement. The method is rapid with flaw detection time as short as a few seconds. The development of this inspection method is supported by extensive experimental and theoretical work on flaw detectability and imaging.

4 TECHNIQUES OF INFRARED THEROGRAPHY

4.1 Infrared thermography is considered either passive or active depending upon the technique employed.

4.2 In passive thermal imaging technique, no externally heat or cool the object under investigation to obtain a thermal profile. Presence of flaw is indicated by an abnormal temperature in the vicinity of a flaw.

4.3 Greater the impedance of the material to heat flow better will be the detection of the flaw present. Higher resistance to heat flow changes temperature more slowly under fixed thermal input. Greater the temperature is observed near a surface flaw.

4.4 The objects that are examined using heating or cooling effects inherent in normal service are considered active. The purpose of examining active objects during service is usually to detect and measure harmful hot spots, rather than to detect only flaws.

5 CALIBRATION AND CHECKING

The system for direct measurement of temperature has to be calibrated with black body calibration. Later for determining exactly the temperature of object under investigation, it should be compared with contact temperature measuring instruments like thermocouple, resistance temperature detectors (RTD) etc. especially in a process plant for inputting the exact emissivity of the object.

6 SIGNIFICANCE AND USE

This guideline can be used by an end user to specify the condition monitoring of rotating components using infrared thermography method:

a) This guideline gives the combined responsibilities of the end user and the infrared thermographer when using infrared thermography method.
b) The aim of an infrared thermography inspection is to identify and document the flaw locations during condition monitoring of rotating components.
c) In mechanical systems, hotspots are usually created by friction caused by improper lubrication, misalignment, worn components or mechanical loading anomalies. Cool exceptions are usually caused by failed components.
d) Infrared thermography inspections give data about equipment at the time of examination only.
e) Infrared thermography inspection is not a solution. It can give the status of the components inspected.

7 PROCEDURE

This guideline can explain the procedure for operation and history of the equipment to be examined:

a) The infrared thermography personal shall develop an inventory list of the equipment to be examined in a logical, efficient and safe route through the facility.
b) The infrared thermography personal shall perform a calibration test(s), before each quantitative infrared examination, to ensure that all temperature measuring equipment is within the manufacturers' standard specifications for accuracy.
c) When examining the components, the thermographer will comply with all safety rules, regulations and practices of the end user.
d) The infrared thermography personal shall make examinations when the environmental and physical circumstances, such as wind, surface and atmospheric moisture and heat transfer are satisfactory to acquiring accurate data.

8 REPORT

The infrared thermographer shall provide documentation for all infrared inspection. The following information shall be included in a report to the end user:

a) The name, organization, address, and telephone number of the infrared thermography personal and his/her certification level and number, if applicable.

b) Name and details of the end user.
c) Details of infrared imaging system used such as manufacturer, model and serial number.
d) The date(s) of the inspection and when the report was prepared.
e) For performing the qualitative measurement of infrared thermal imaging data, the personal should note down the ambient temperature and the sky conditions at the time of the examination.
f) The time at which the experiment was conducted.
g) Hardcopies of the thermal images with detail temperature scale and the corresponding normal photographic image.
h) Field of view of the infrared camera lens, and any zoom settings that could affect the accuracy, reliability, or repeatability of the inspection data.
j) While performing quantitative infrared inspections, the infrared thermographer shall note down the distance of the object from the infrared camera, the reflected temperature, emissivity and transmission values used to calculate the temperature(s) of the object.
k) The actual temperatures of surfaces having low emissivity may differ from corrected radiometric measurements.

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